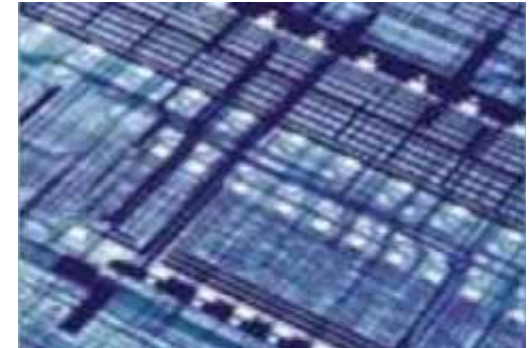


Simplify the Last HDMI Compliance Testing

- Tektronix HDMI CTS1.3c Test Solution

HDMI™
HIGH-DEFINITION MULTIMEDIA INTERFACE



Tektronix HDMI CTS1.3c Test Solution

- Agenda
 - HDMI Overview and updates

 - Compliance Test Solution
 - **Source Tests**
 - Tektronix Recommended Test Equipment for source

 - **Sink Tests & Cable Tests**
 - Tektronix Recommended Test Equipment for Sink & Cable

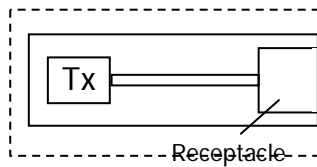
 - Solution Details

 - Additional resources

HDMI – System Overview



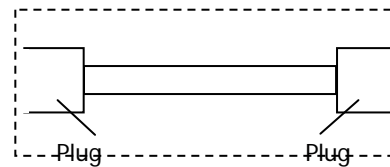
Source Devices



- Set-top Boxes, DVDs, Repeaters, Gaming devices



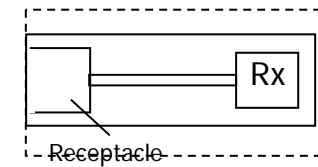
Cable Assemblies



- Cables



Sink Devices



- TVs, Monitors, Repeaters, etc.

HDMI Technology and solution status

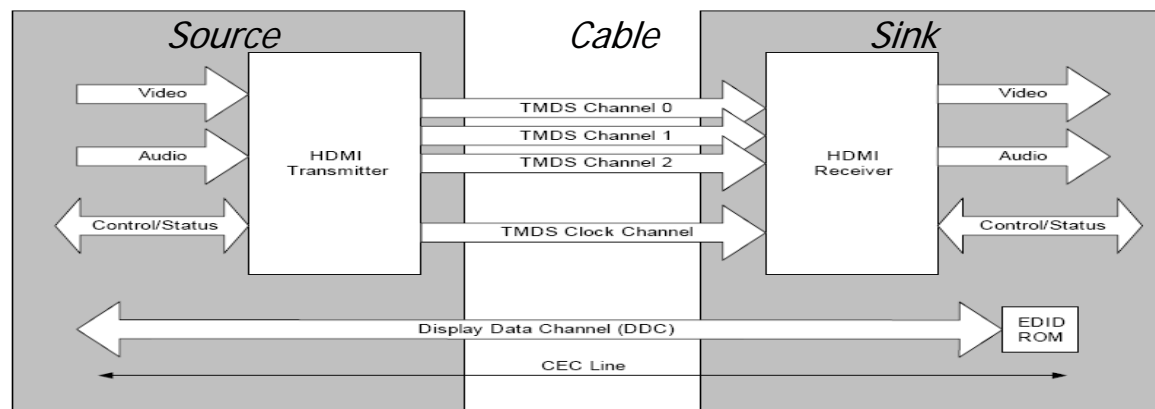
- Over 800+ adopters till date and expected to cross 1000 very soon.
- HDMI making inroads into PC industry
 - New Intel platforms have HDMI interfaces
- Hand held devices with miniature HDMI devices
 - New connectors in the pipeline
- Faster data rates for hand shaking signals
- Higher data rates (4.5G) likely in 18 months timeframe??
- Wireless HDMI (Wimedia, Wireless USB etc)
- WiHD (60GHz LOS)
- WHDI (5GHz)
- D I V A (Different from HDMI)

HDMI v1.3 Specifications and Compliance Test Specifications – What's Changed

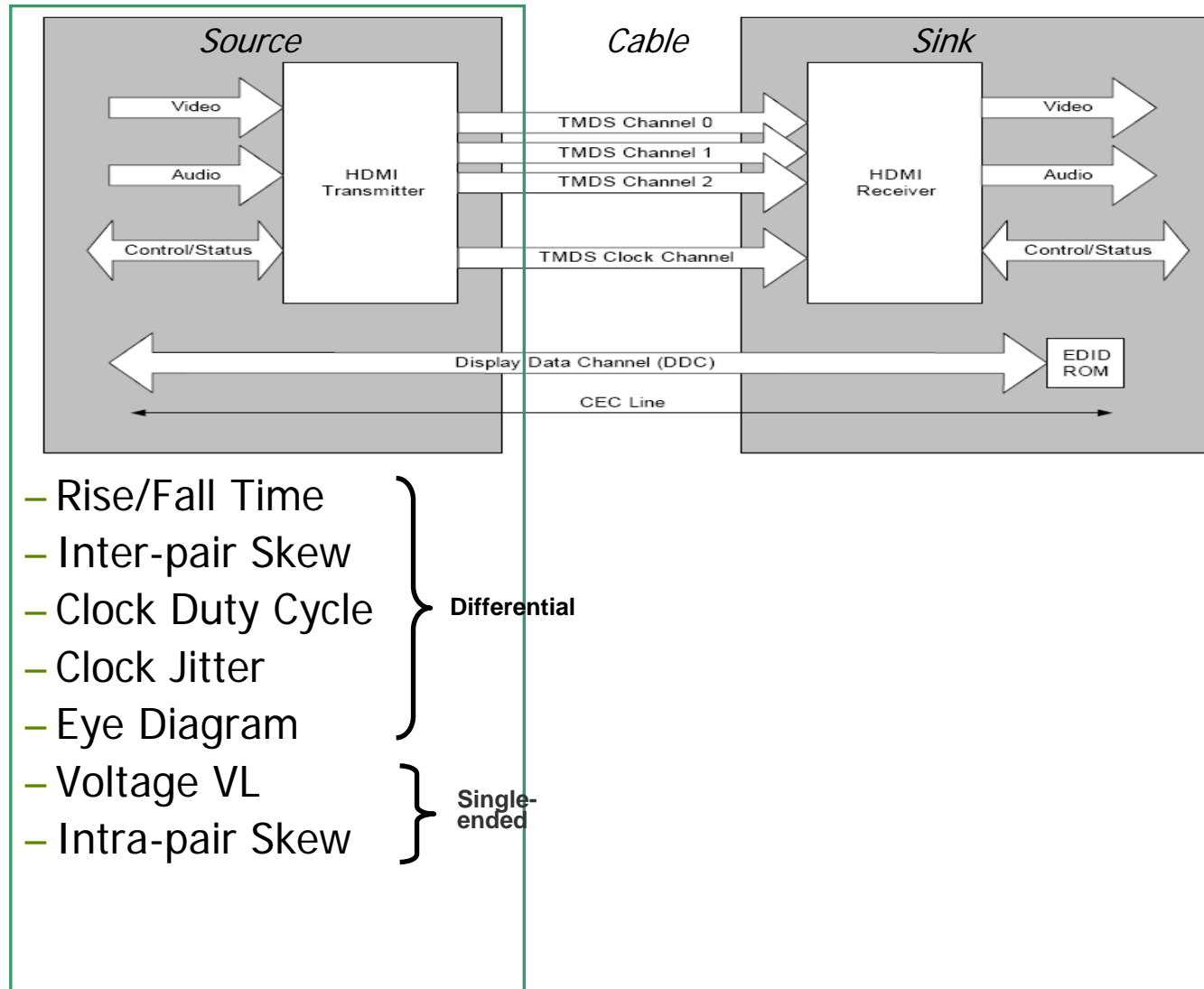
- The HDMI v1.3 Specification was announced in June 2006
- Compliance Test Specification
 - CTS 1.3a released in November, 2006
 - CTS 1.3b announced in March 26, 2007
 - CTS 1.3b1 announced in Aug 1, 2007
 - **CTS1.3c announced on July 25th 2008 – Approves Direct Synthesis method for Sink testing**
 - Tektronix now has the compliance software as per CTS1.3b1.(HT3 ver 4.0.0)
 - HT3 Software with Direct Synthesis HDMI solution will be available soon.
- Key improvements in HDMI v1.3
 - TMDS clock rates up to 340MHz from the previous 165MHz
 - Faster refresh rates
 - Deep color support (extended from 8 bit color to 10, 12 and 16 bits)
 - Support for miniature HDMI connector for handheld devices
- Updated testing requirements
 - Cable equalization mandated for cable tests and Sink tests, for clock rates above 165MHz
 - Eye diagram is now a fixed amplitude eye diagram compared to the normalized eye in the past
 - Clock - Data Inter Pair Skew test removed
 - Under shoot and Overshoot tests removed
 - Maximum rise time / fall time test removed
 - Modified Sink Jitter tolerance test(CTS 1.3b)
 - Modified cable test (CTS 1.3b)
 - Added Efficere Type C fixture in CTS1.3b1
 - **Included Direct Synthesis Solution in CTS1.3c**

Tektronix Brings Domain Expertise to HDMI Test

- Unequaled domain expertise
 - Providing leading HDMI test solutions since original HDMI spec introduced
- Portfolio of solutions
 - Complete solution for physical layer testing
 - Performance ideally suited for HDMI testing
 - Signal generators, real-time oscilloscopes, compliance test software, TDR, sampling oscilloscopes & probing
- Cost effective, flexible
 - More affordable upgrade path from previous HDMI test systems
 - Flexible test configuration (e.g., Sink Jitter tolerance tests can use AFG3102, AWG710/B or AWG7102)
- Reduce test time
 - Automation of the more challenging tests
 - Four-lane Sink Intra-Pair Skew Test



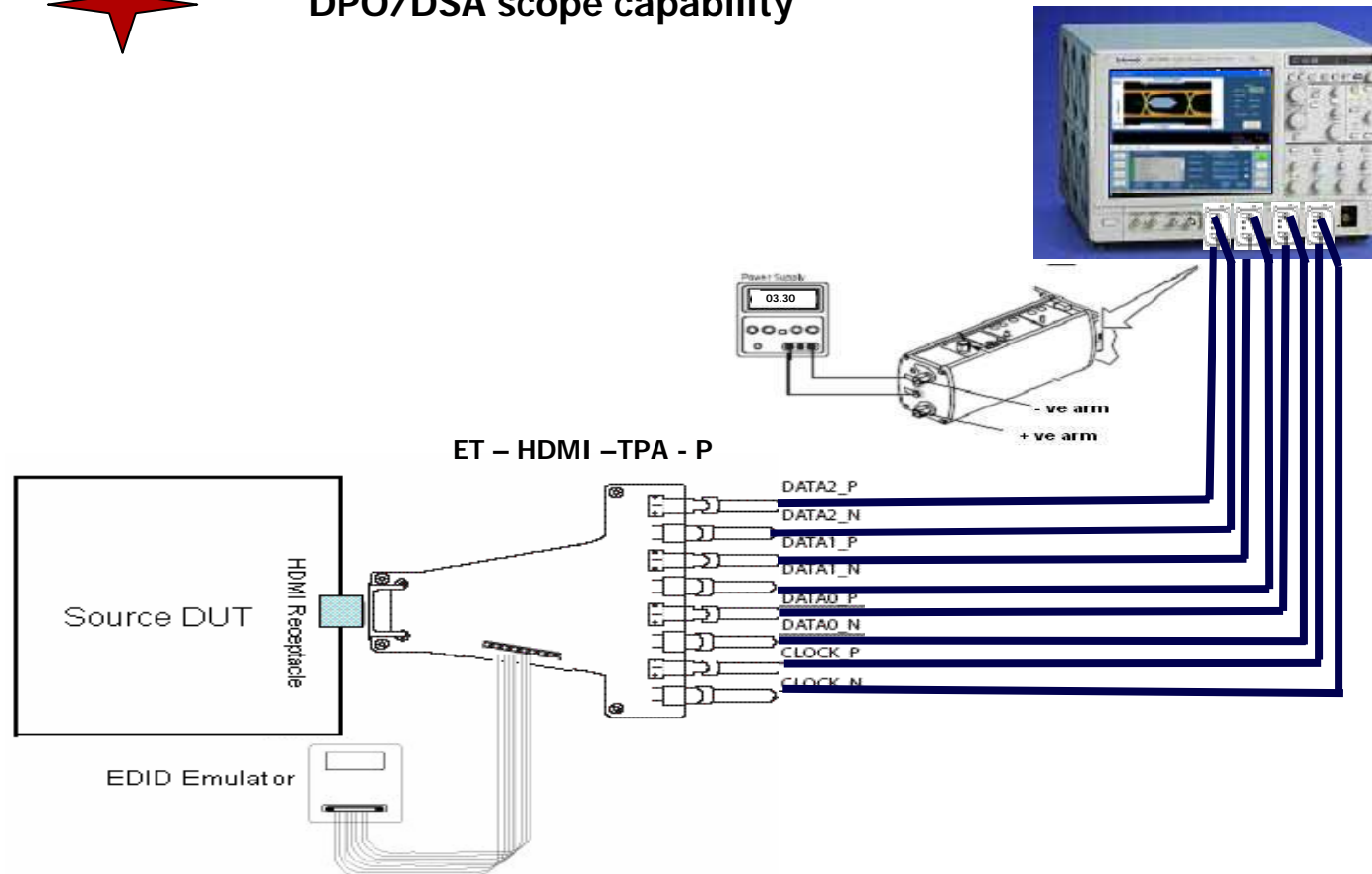
HDMI Source Testing



Typical Source Test Configuration

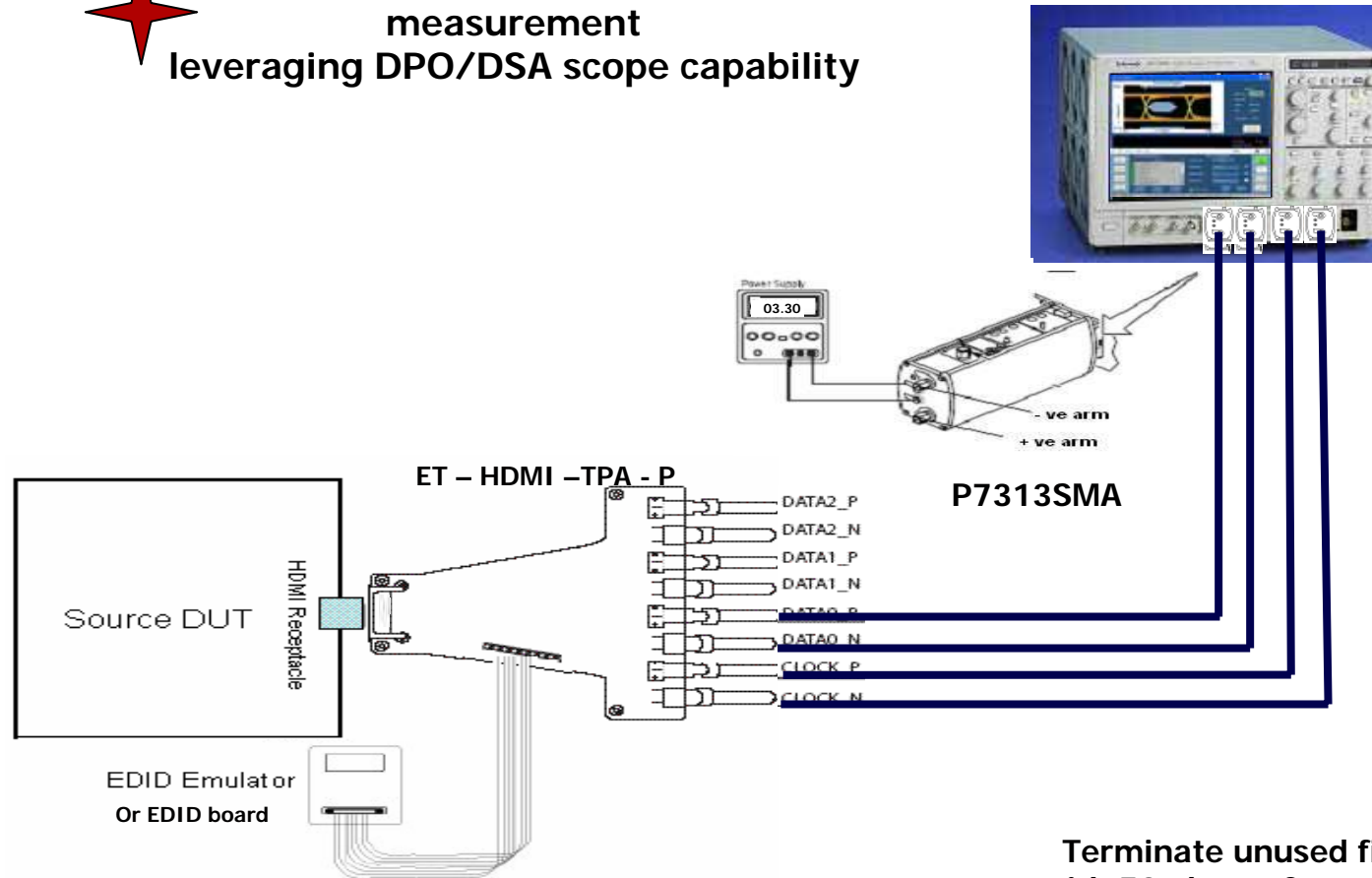
Differential Measurement

Introducing 4 channel support for
Differential measurement leveraging
DPO/DSA scope capability



Typical Source Test Configuration *Single-ended Measurement*

★ Introducing 2 channel support for SE measurement
leveraging DPO/DSA scope capability



Terminate unused fixture connectors
with 50 ohms after pulling them to 3.3V
using Bias-Tees

HDMI CTS1.3b1 – Source Test

Recommended Tektronix Equipment

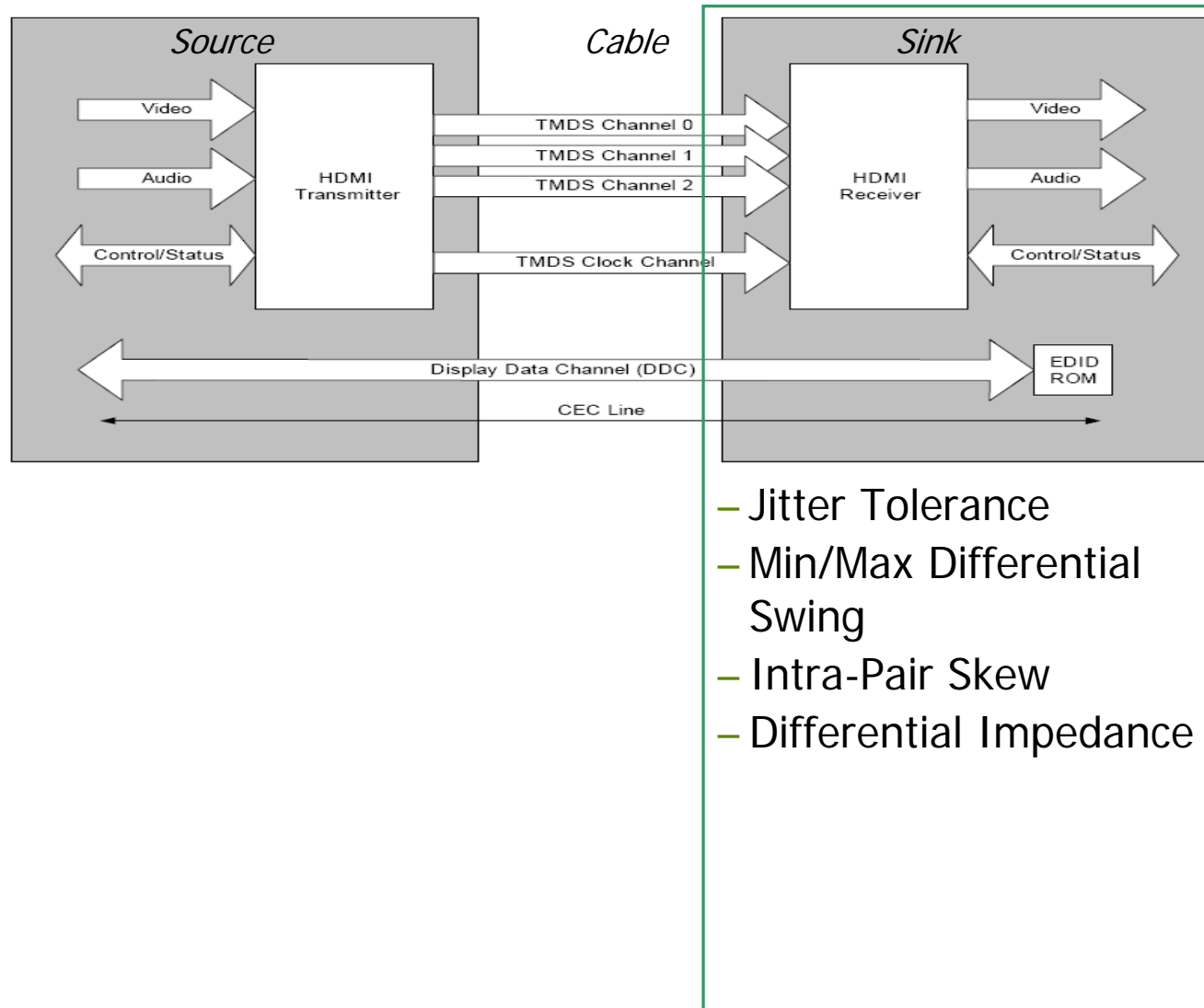
- See http://www.tek.com/Measurement/applications/serial_data/hdmi/vi/source_test.html for current, detailed list

Recommended Equipment		Quantity
Real-Time Oscilloscope	DSA70804 or DSA71254 or DSA71604 or DSA72004 or DPO70804 with Opt 2XL or DPO71254 With Opt 2XL: or DPO71604 with Opt 2XL or DPO72004 with opt 2XL	1
Other supported RT oscilloscopes ^{1, 2}	TDS6804B, TDS6124C and TDS6154C	1
Software	TDSHT3 HDMI compliance software (software v3.3.0 or higher)	1
Probes	P7313SMA differential SMA probe - use for all differential and single-ended measurements.	Minimum 2
Test Fixtures	TPA-P TPA-R and EDID fixtures from Efficere Technologies. Order a set as ET-HDMI-TPA-S	1 set
Power supply	3.3V power supply	1
Connector	Bias-Tees to terminate the unused fixture ports	8 pcs

¹ Oscilloscopes with bandwidth less than 8 GHz will only support HDMI testing at limited resolution and clock/data rates

² 16M per channel or greater record length is required for HDMI Compliance test

HDMI Sink Testing



Sink Testing

Jitter Tolerance Test



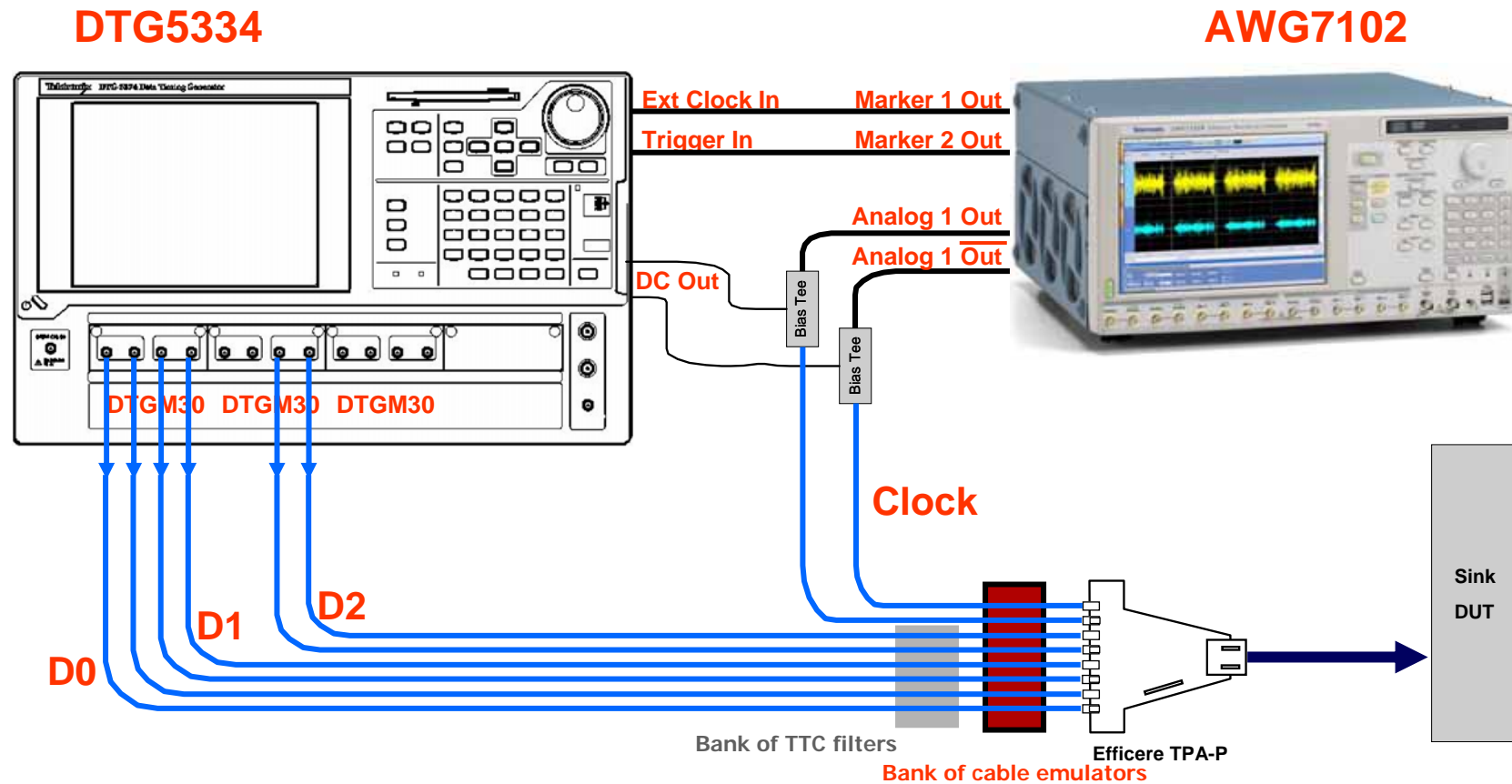
**Introducing margin test capability for
SJT with Max of 0.5TBit Jitter for Cj
and Dj**

- Test sequence has been simplified
 - Requires fewer iterations to complete a test (eliminated Djw procedure)
 - CTS1.3b1 adds TP2 testing
- Supports two alternative methods of jitter injection
 - Standard Jitter insertion method
 - Combines both clock and data jitter components and modulates them both on the clock signal
 - Minimum test requirement of CTS - HDMI customers
 - Optional Jitter Insertion method
 - Modulates clock signal only with clock jitter component
 - Modulates all data signals with data jitter component
- *Tektronix Status:* Our HDMI compliance solution for CTS V1.3b1 testing supports both methods
 - The standard method is supported at minimal cost using an AFG3102 or AWG710/B for customers who already have them
 - The new AWG7102 with Option 01 supports both methods.

Jitter Generation with DTG & AWG7102 (combined clock/data jitter)

27 MHz to 340 MHz

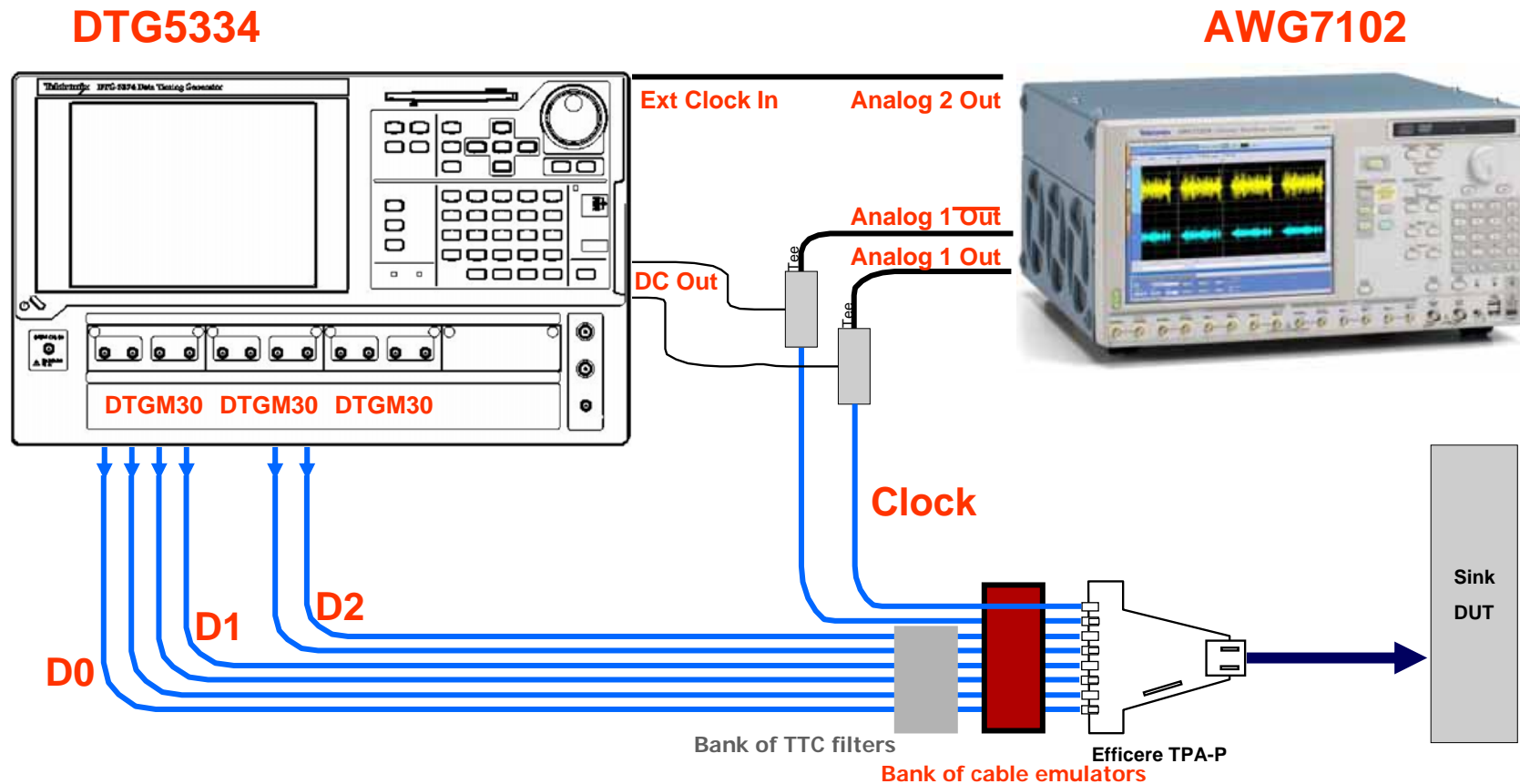
- AWG CH1 - Sub-rate (1/10 data rate) clock modulated with both clock jitter component (10 MHz/7 MHz) and data jitter component (500 KHz/1 MHz)
- AWG MK1 - Full rate clock to DTG



Jitter Generation with New Equipment (*separate clock/data jitter*)

27 MHz to 340 MHz

- AWG CH1 - Sub-rate (1/10 data rate) clock modulated with clock jitter component (10 MHz/7 MHz)
- AWG CH2 - Full rate clock to DTG modulated with data jitter component (500 KHz/1 MHz)



HDMI CTS1.3b1 – Sink Test

Recommended Tektronix Equipment

- See http://www.tek.com/Measurement/applications/serial_data/hdmi/vi/sink_test.html for current, detailed list

Recommended Equipment		Quantity
Real-Time Oscilloscope	DSA70804 or DSA71254 or DSA71604 or DSA72004 or DPO70804 with Opt 2XL or DPO71254 <i>With Opt 2XL:</i> or DPO71604 <i>with Opt 2XL</i> or DPO72004 <i>with opt 2XL</i>	1
<i>Other supported oscilloscopes</i> ^{1, 2}	<i>TDS6804B, TDS6124C and TDS6154C</i>	1
Software	TDSHT3 HDMI compliance software (software v3.3.0 or higher)	1
Probes	P7313SMA differential SMA probe - use for all differential and single-ended measurements	Minimum 2
Data generator	DTG5334 with (3) DTGM30 modules	1 set
<i>Other supported data generators</i> ³	<i>DTG5274 with (3) DTGM30 modules -- will only support HDMI testing at limited resolution and clock/data rate</i>	1 set
Jitter generator	AWG7102 with opt 01 - supports both standard (combined) and Optional (separate clock/data) Jitter insertion methods	1
<i>Other supported jitter generators</i>	<i>AFG3102 or AWG710B - these support only the standard (combined clock/data) jitter insertion method</i>	1
TDR system	DSA8200 with (1) 80E03 and (1) 80E04 module (for SINK Differential Impedance test)	1
Test fixtures (TPAs)	TPA-P TPA-R and EDID fixtures from Efficere Technologies . Order a set as ET-HDMI-TPA-S	1 set
Connector	Bias-Tees to shift AWG7102 direct clock output to TMDS levels. Order individually as ZX85-12G-S+ from Mini-Circuits	2
Cables	SMA cables	12
Adapter	BNC to SMA adapter	1
Interface ⁴	NI-GPIB-USB -A/B/HS with Driver Software from National Instruments or NI-ENET	1
Power supply	Power supply 5V	1
Filters	Transition Time Converters from Picosecond Pulse Labs	6 sets

1 Oscilloscopes with bandwidth less than 8 GHz will only support HDMI testing at limited resolution and clock/data rates.

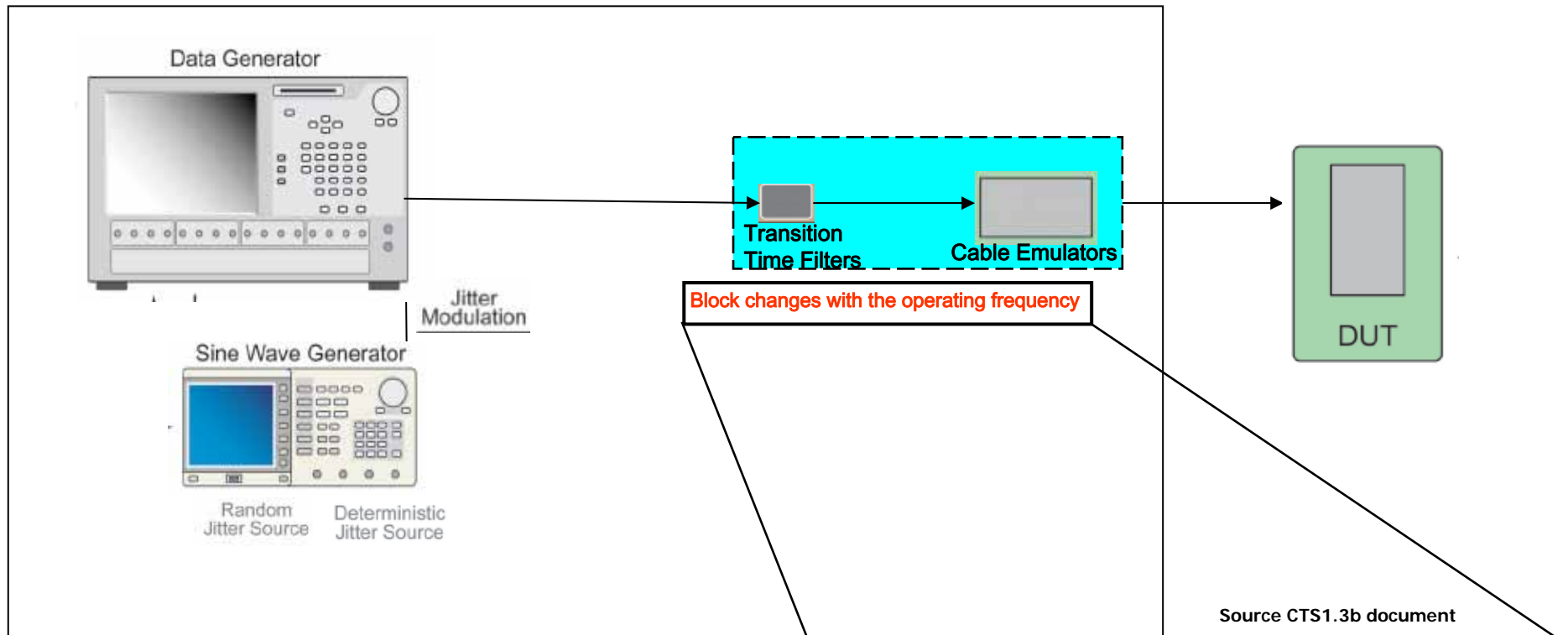
2 16M per channel or greater record length is required for HDMI Compliance test.

3 If the Jitter Generator used is an AFG3102 or an AWG710B, then a single DTGM32 module is also required for use with either DTG model.

4 Type B/HS is recommended for use with DPO/DSA70000 series oscilloscopes.

Introducing Direct Synthesis HDMI Sink Solution- Now approved in CTS1.3c

Present Solution-HDMI Sink Jitter Tolerance setup



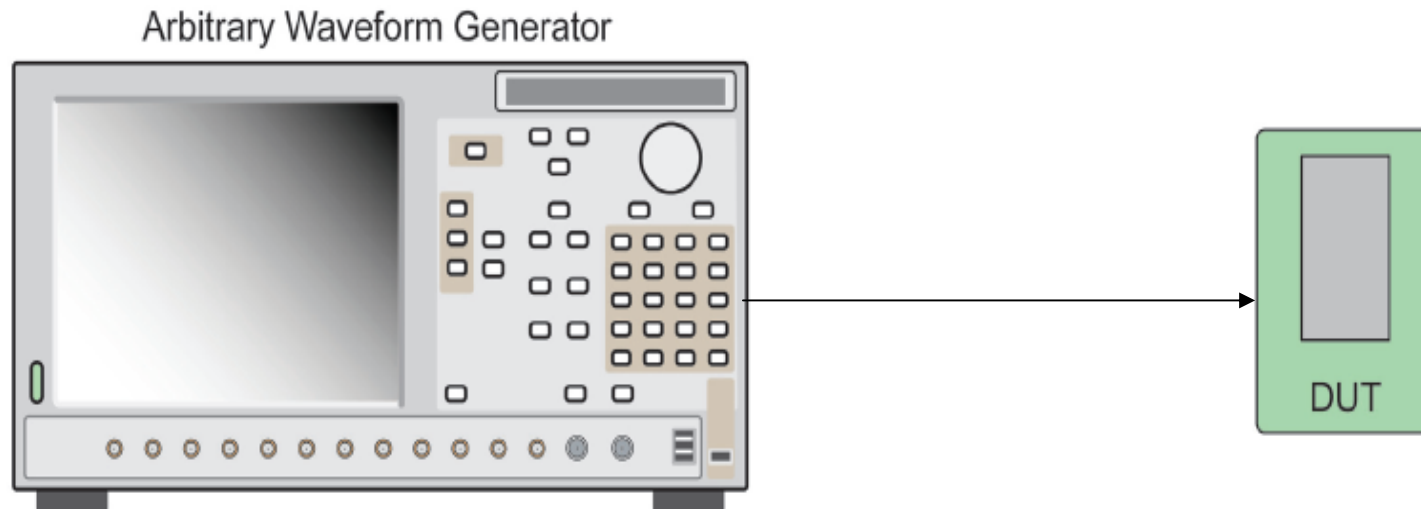
Can we reduce the **complexity** ?

Can we save the setup **time** ?

Can we provide **cost effective** solution ?

Typical (MHz)	Low (MHz)	High (MHz)	TTC (MHz) ¹	1 st Cable Emulator	2 nd Cable Emulator
27	>= 25	<=27.1	74.25	Type 1 Cat1+Cat2 (Agilent) ²	Type 2 27MHz (JAE)
74.25	>= 27.1	<=74.25	74.25	Type 1 Cat1 (Agilent)	Type 2 75MHz (JAE)
148.5	>74.25	<=165	148.5	Type 1 Cat2 (Agilent)	Type 3 (Agilent)
222.75	>165	<=222.75	222.75	Type 1 Cat2 (Agilent)	Type 3 (Agilent)
340	>222.75	<=340	340	Type 1 Cat2 (Agilent)	Type 3 (Agilent)

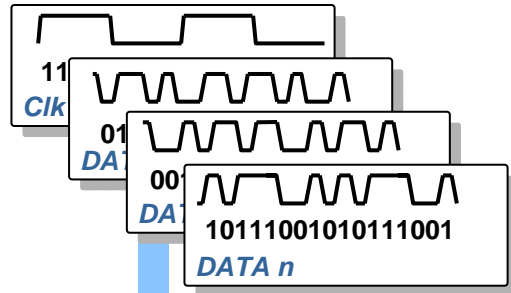
Equipment configuration for Direct Synthesis



- **No Hardware Cable emulator**
- **No Hardware TTC filters**
- **Synthesize directly using the next gen DS method**

Direct Synthesis – HDMI Waveform Generation

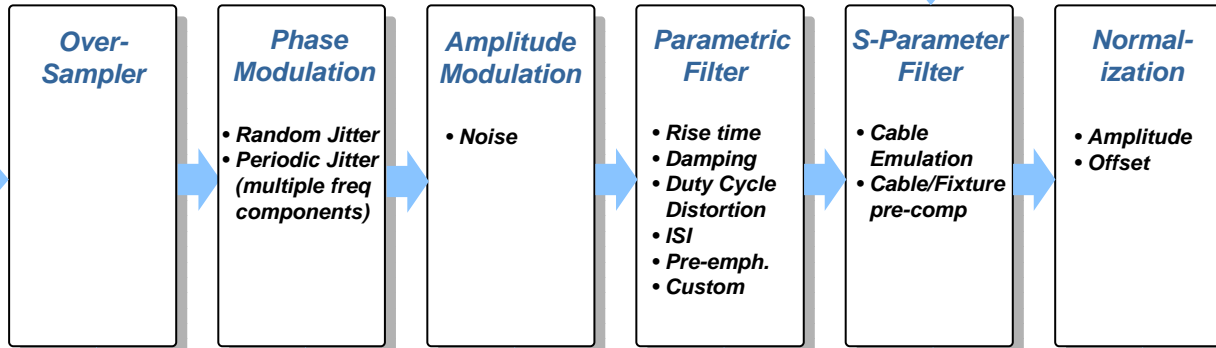
Digital Patterns



TDR
with IConnect®

Touchstone
File

Direct Synthesis Waveform Generation Tool



Waveform
File

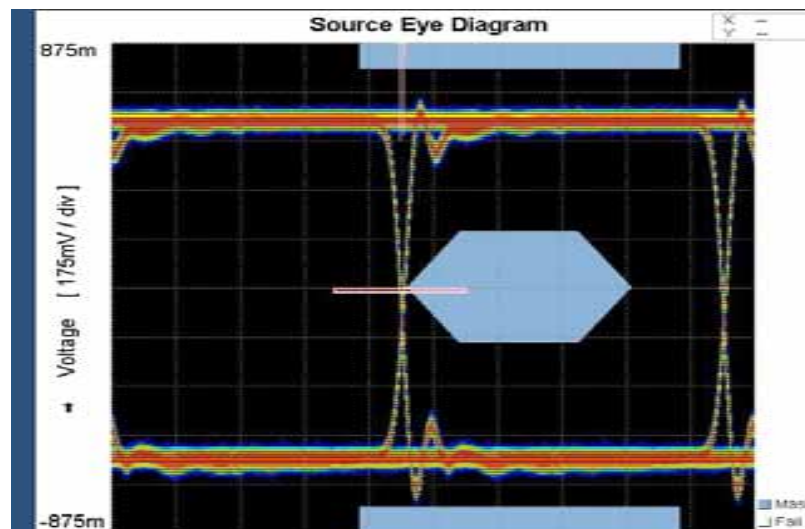


Binary
Pattern
File

User-specified Input Parameters

Signal Generation Solution with Direct Synthesis

- Direct Synthesis is currently employed in other serial standards
 - SATA II and Display Port...
- HDMI requires more channels and more complex waveforms
- HDMI Configuration is two AWG7102 units plus AFG3000
- Can be configured for all tests requiring TMDS Signal Generator
 - Cable Eye Diagram
 - Sink Jitter Tolerance
 - Sink Min/Max Differential Swing Tolerance
 - Sink Intra-pair Skew

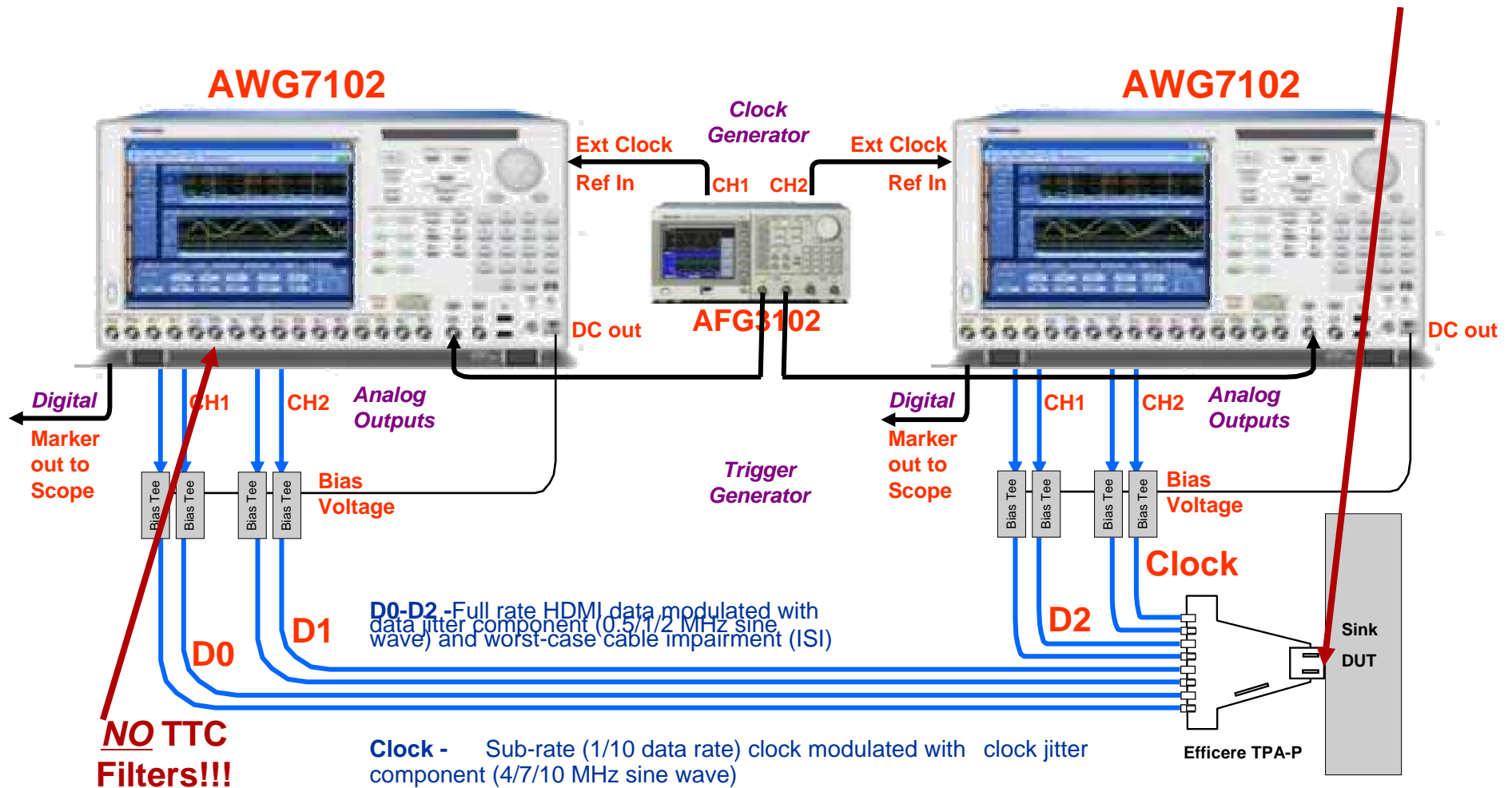


Results	
Mask Test	PASS
Mask Hits	0
Vswing	1.2157V
Tbit	1.3490ns
Data Jitter	23.4ps
Hist Pk-Pk	23.4ps

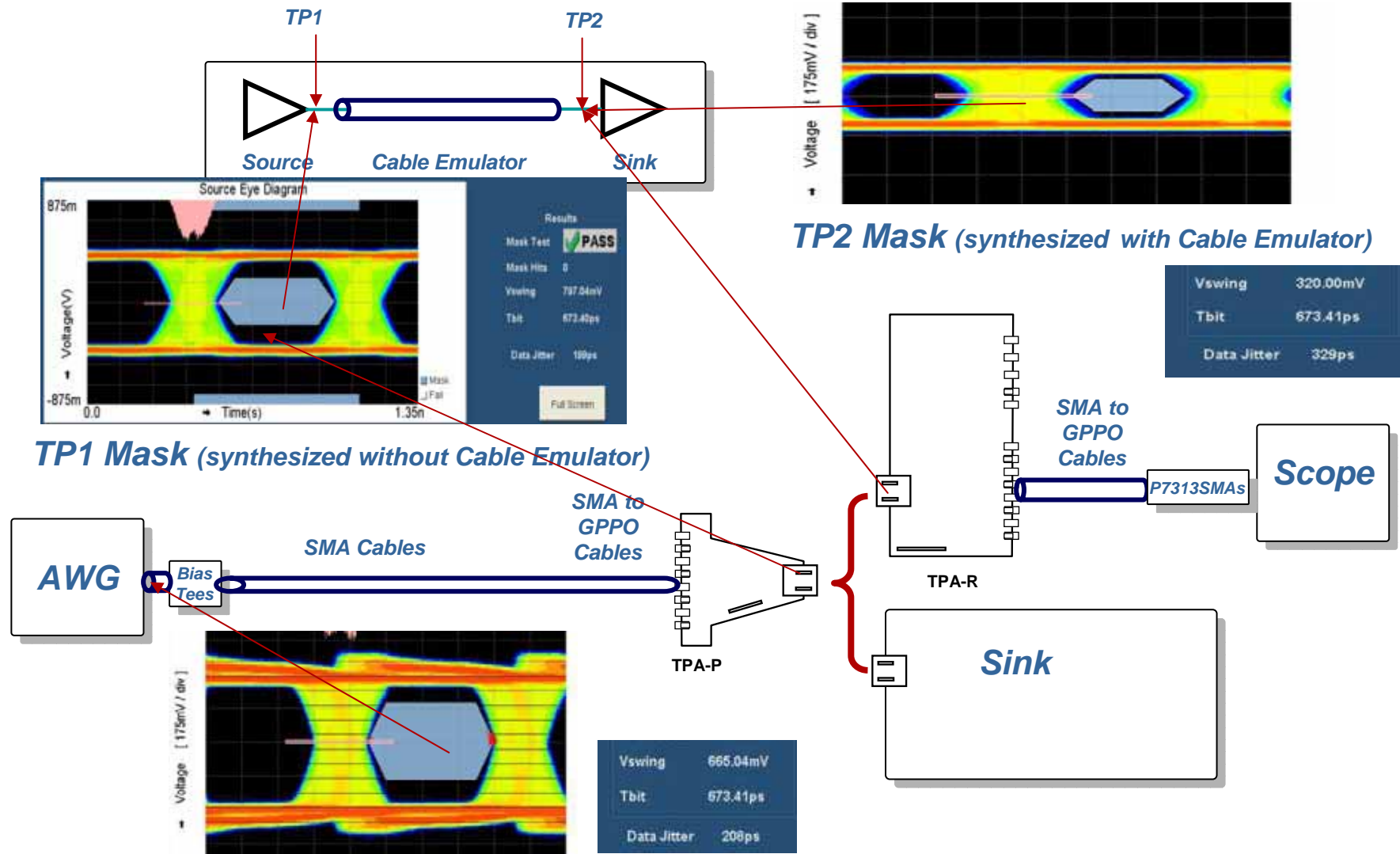
HDMI Jitter Tolerance Test with Direct Synthesis (also used for Cable Eye Diagram)

27 MHz to 340 MHz

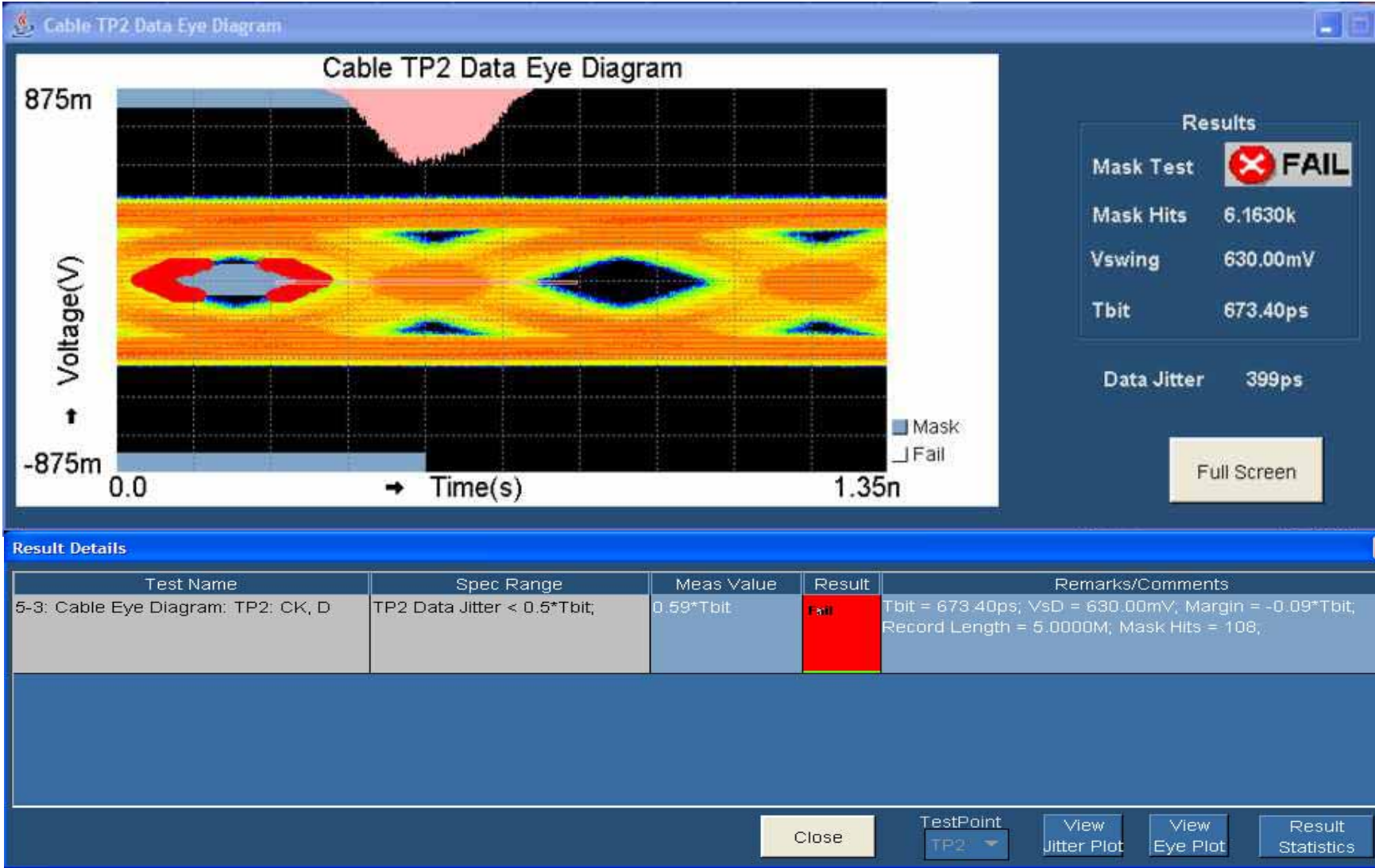
NO Cable Emulator!!!



Direct Synthesis - HDMI Sink Jitter Tolerance Test



Ability to add Jitter as required



Benefits of Direct Synthesis

- It greatly simplifies the test configuration
 - eliminates Cable Emulators
 - eliminates most, if not all Transition Time Converters
 - The cost savings offset much of the extra AWG cost
 - DTG
 - DTGM30 modules
 - DTGM32 module
 - Cable emulators (8 channels x 2 cable types)
 - ~40 transition time filters
- It greatly reduces the number of connection changes required for Sink testing
 - No need to change TTC's, Cable emulators, etc.
 - Much faster test time
 - Greatly reduces the opportunity for operator error
- It offers far greater flexibility.
 - Can generate a wide range of rise-times without different filters
 - Supports both the Combined and the Separate clock/data jitter insertion methods
 - Can synthesize any/all Cable Emulator (even when requirements change)
 - Can emulate old Cable Emulators or competitive ones for correlation
 - Can change the waveforms quickly to emulate any impairment the CTS requires in the future
 - Can generate pre-emphasis
 - Enables customers to perform their own margin testing
- It offers better test repeatability across multiple labs/locations (fewer pieces that can vary)
- It eliminates concerns about inherent jitter of the DTG5334
- It offers headroom for future test requirements (pre-emphasis, faster rates, etc.)
- It enables users to characterize their test setup (cables, fixtures, etc.) and then pre-compensate their waveforms to produce signals that are correct at the DUT launch point, rather than at the instrument front panel

HDMI CTS1.3c – Sink Test

Recommended Tektronix Equipment for Direct Synthesis

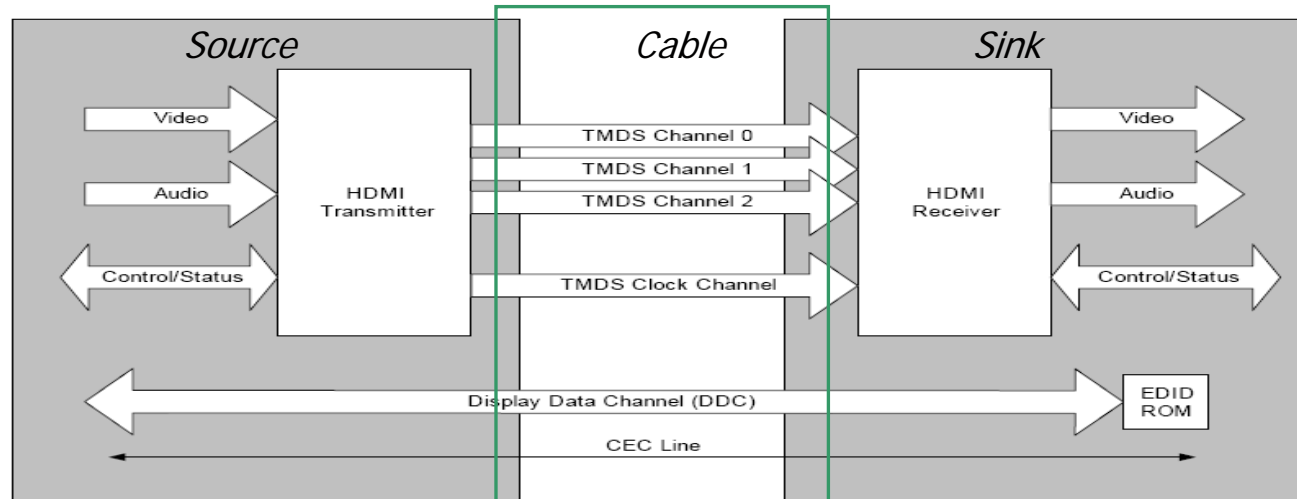
Recommended Test Equipment #4 – For testing only Type 2 cable emulator test in Test ID 8-7

- (2) Tektronix AWG7102 Arbitrary Waveform Generators (AWG) with Opt 01 and 06.
- (1) Tektronix AFG3102 Arbitrary Function Generators (AFG)
- (8) Mini Circuits Bias Tee model number ZX-85 12G+ needed to connect to the output of the AWG analog ports
- (10 or 12) SMA Cables: Tektronix 174-1428-00 (1.5 meters), as needed to connect output of Bias Tees to Efficere TPA boards .
- (1) DC Power Supply: To Connect 5V to the +5V Power (P_5V) and DDC/CEC Ground (P_GND) on TPA-P.
- (1) Tektronix HDMI Fixture Set ET-HDMI-TPA-S
- (1) HT3 software version with Direct Synthesis capability.

Summarize

- Direct Synthesis method in HDMI reduces the complexity and long test times particularly for Sink Jitter Tolerance test.
- Repeatability is ensured and in case of multi location sites only the AWG setup files need to be made available to get consistent results across locations.
- Direct Synthesis method in HDMI has future proof in case there are new CE added to the testing. The same can be synthesized in the direct synthesis method.
- The Test Equipments that is used for HDMI DS setup (DSA70804, AWG7102 opt 1,6) is used in testing other standards like Wimedia, Display Port, SATA, PCI-E etc thus providing cost effective solution.

HDMI Cable Testing



- TMDS Data Eye Diagram
- Inter-pair and Intra-pair Skew
- Impedance
- FEXT (Far End Crosstalk)
- Attenuation

Cable Tests

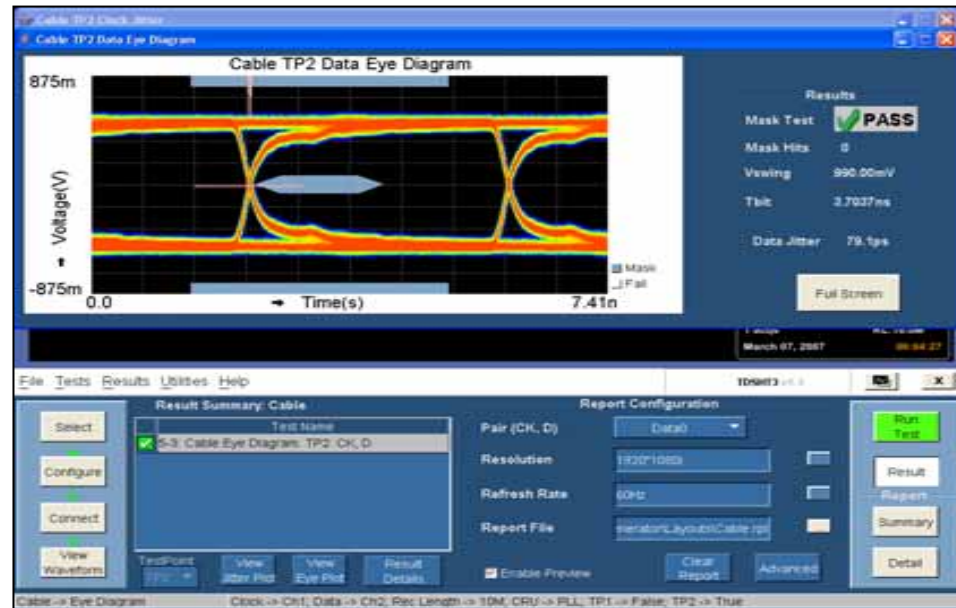
Introducing 4 channel support for TP2
Eye Diagram test
leveraging DPO/DSA capability



- TMD5 Data Eye Diagram



Introducing AFG support for Jitter
insertion for Cable Eye Diagram test



- Others
 - Inter-pair and Intra-pair Skew
 - Impedance
 - FEXT (Far End Crosstalk)
 - Attenuation



Performed Using TDR Oscilloscope



Performed Using Network Analyzers

Can be accomplished with TDR/IConnect
(pending approval for inclusion in CTS)

HDMI CTS1.3b1 – Cable Test

Recommended Tektronix Equipment

- See http://www.tek.com/Measurement/applications/serial_data/hdmi/cable_test.html for current, detailed list

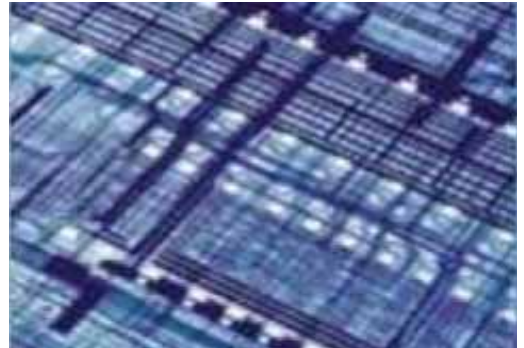
Recommended Equipment		Quantity
Real-Time Oscilloscope	DSA70804 or DSA71254 or DSA71604 or DSA72004 or DPO70804 with Opt 2XL or DPO71254 <i>With Opt 2XL:</i> or <i>DPO71604 with Opt 2XL or DPO72004 with opt 2XL</i>	1
<i>Other supported oscilloscopes ^{1, 2}</i>	<i>TDS6804B, TDS6124C and TDS6154C</i>	1
Software	TDSHT3 - HDMI compliance software (software v3.3.0 or higher)	1
Probes	P7313SMA differential SMA probe - use for all differential and single-ended measurements	Minimum 2
TDR system	DSA8200 with (1) 80E03 and (1) 80E04 module (for Cable Inter-pair/Intra-pair Skew and Differential Impedance tests)	1
Test Fixtures	TPA-P TPA-R and EDID fixtures from Efficere Technologies . Order a set as ET-HDMI-TPA-S	1 set
Cables	SMA cables	4
Modules	DTG5334 with 3 DTGM30 modules	1 set
Filters	Transition Time Converters from Picosecond Pulse Labs	8 sets
Interface	NI-GPIB-USB - A/B /HS with Driver Software from National Instruments or NI-ENET	1

1 Oscilloscopes with bandwidth less than 8 GHz will only support HDMI testing at limited resolution and clock/data rates.

2 16M per channel or greater record length is required for HDMI Compliance test.

3 Type B/ HS is recommended for use with DPO/DSA70000 series scopes.

Tektronix Solution Details



Real-Time Oscilloscopes & Probes

- Multiple performance offerings
 - ≥ 8 GHz bandwidth for testing at all rates covered in CTS v1.3b1
 - ≥ 4 GHz bandwidth for testing clock rates up to 148.5 MHz
 - Sample rate 25 GS/s or 50 GS/s
 - Specific Record Length option required for efficient operation: 16M on two channels

- Real-time oscilloscope needed for Source, Sink and Cable testing
 - 8 GHz: DSA70804, or DPO70804 w/Opt 2XL
 - 4 GHz: DSA70404, or DPO70404 w/Opt 2XL

- P7313SMA Differential SMA probe
 - Performance specifically designed for HDMI testing
 - For all differential and single ended measurements

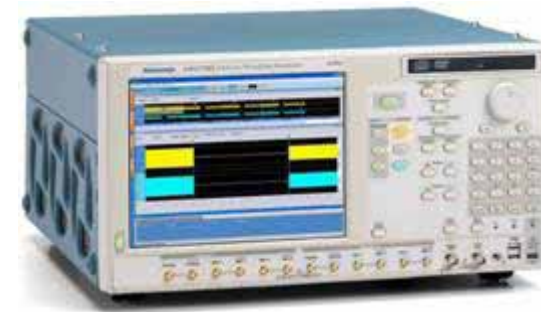


Choosing Real-Time Scope Bandwidth		
Video Format	Bit Rate	R-T Scope BW
1080i 24bit-Color (8bit/Ch)	742.5Mbps	4 GHz
1080p 24bit-Color (8bit/Ch)	1.485Gbps	4 GHz
1080p 30bit-Color (10bit/Ch)	1.86Gbps	8 GHz
1080p 36bit-Color (12bit/Ch)	2.23Gbps	8 GHz
1080p 48bit-Color (16bit/Ch)	2.97Gbps	8 GHz

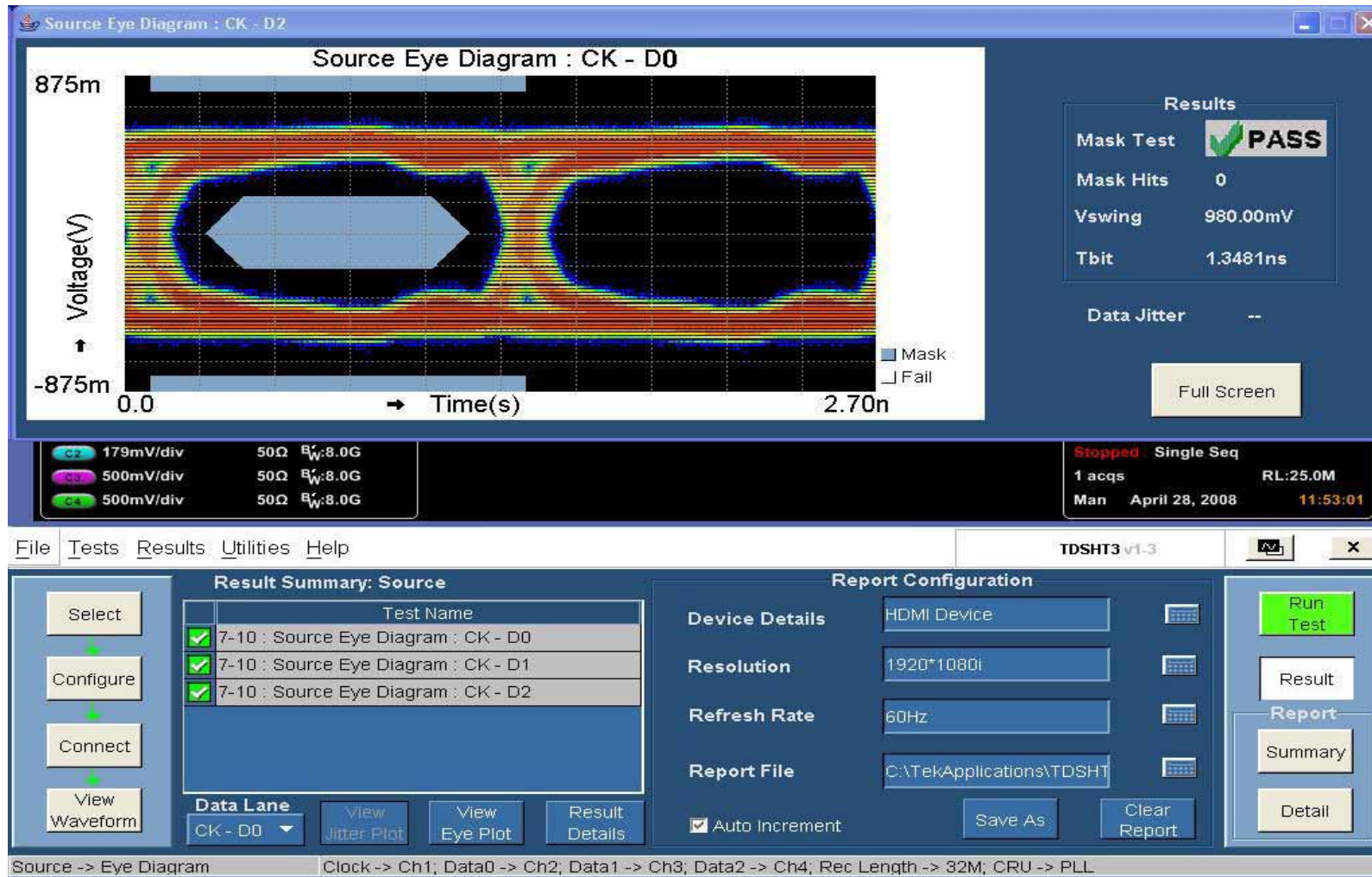


Signal Sources

- HDMI Pattern Generation
 - DTG5334 mainframe
 - DTGM30 modules (three required)
 - DTGM32 (for use with AWG710/B or AFG3102 only)
- Sink Tests - Jitter Injection
 - AWG7102. Highly flexible arbitrary waveform generator with highest resolution and memory available on the market. Supports both separate jitter insertion and composite jitter insertion.
OR
 - AFG3102. Low cost solution but only for composite jitter insertion
OR
 - AWG710/B. Only for composite jitter insertion



TDSHT3 v4.0.0 or above version Software



TDSHT3 v4.0.0 or above version Software

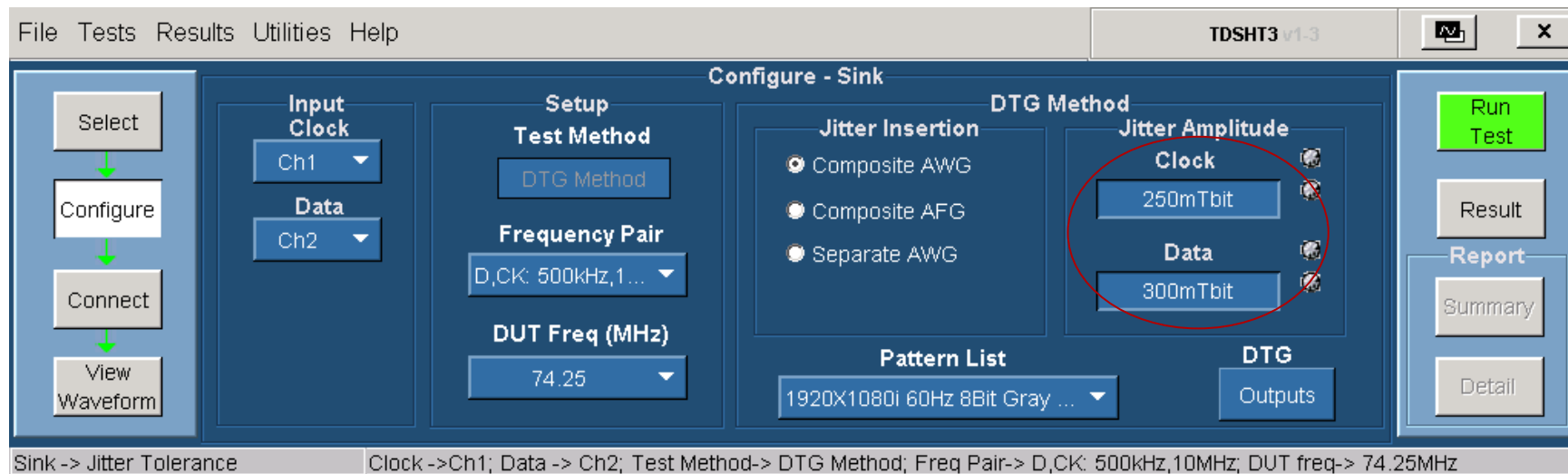
- Source Test



Introducing 4 channel support for Differential measurement & 2 channel SE measurement leveraging DPO/DSA capability

TDSHT3 v4.0.0 or above Software

- Sink Test
 - Sink setup pane with selection of separate and combined jitter insertion and AWG/AFG selection
 - Drop down menu for pattern selection



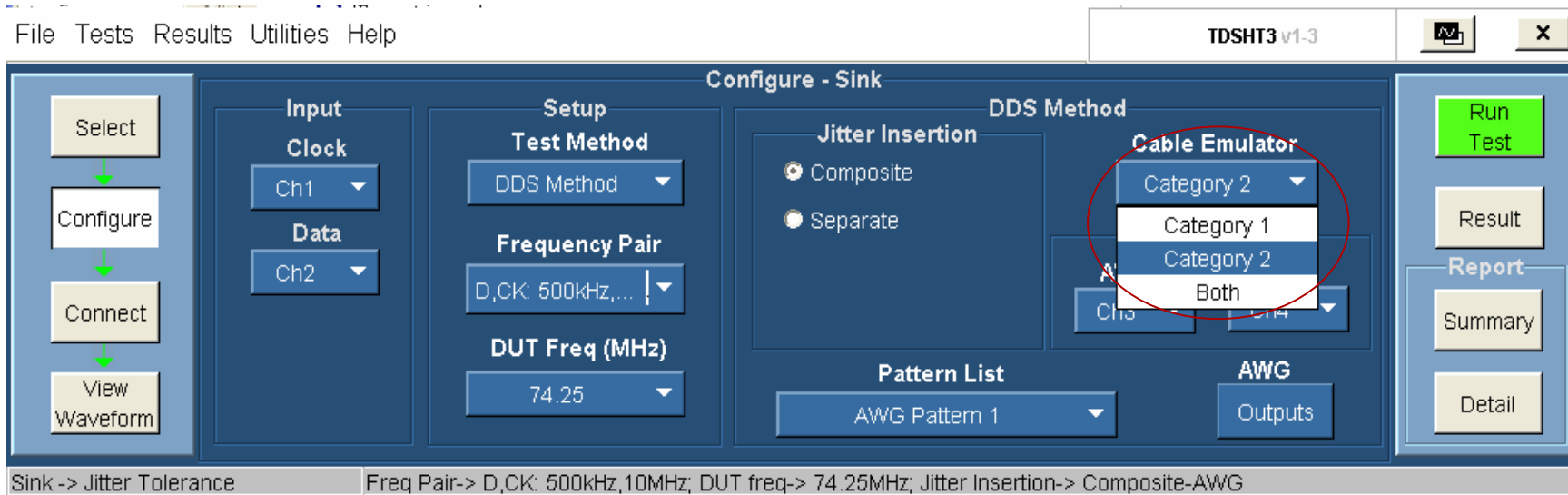
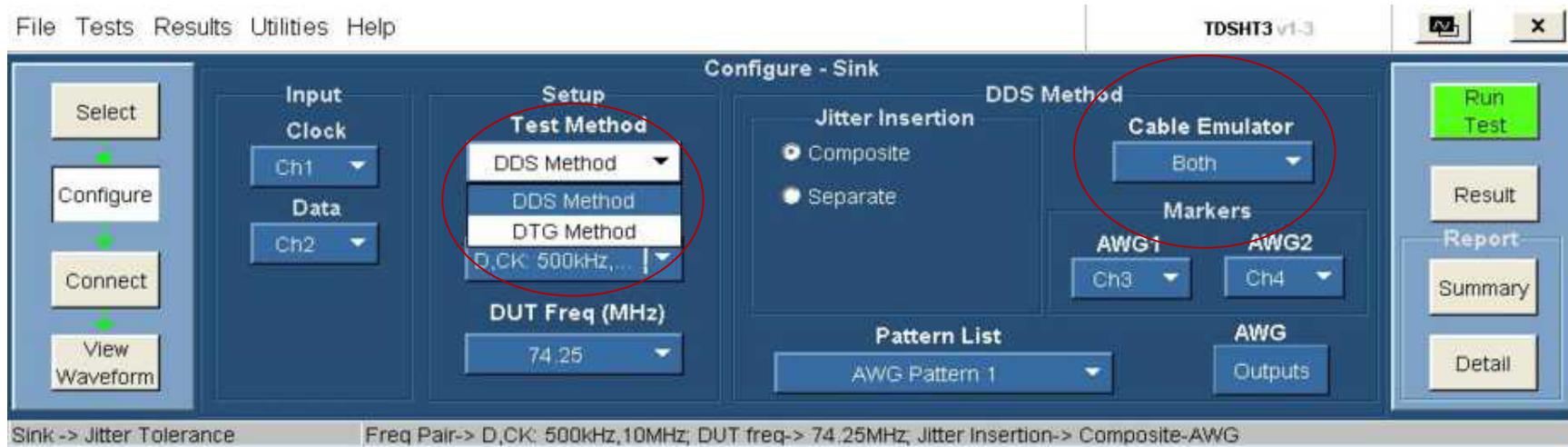
TDSHT3 v4.0.0 or above Software

- Cable Test
 - Cable test with Rise time filter selection (in place of hardware TTC filters) and Cable equalization filter selection

The screenshot shows the 'Configure - Cable' dialog box in the TDSHT3 v1.3 software. The 'Rise time filter' tab is active. The 'Test Method' is set to 'DTG Method'. The 'Horiz/Acq Rec Length' is set to '8.00M'. The 'CRU' is set to 'PLL'. The 'Test Points' section has checkboxes for 'TP1' and 'TP2', both of which are checked. The 'Ref Level Units' are set to 'Per (%)'. The 'High Ref' is set to '80%', 'Mid Ref' is '50%', and 'Low Ref' is '20%'. The 'Hysteresis' is set to '10%'. On the right side, there are buttons for 'Run Test', 'Result', 'Report', 'Summary', and 'Detail'. The status bar at the bottom indicates: 'Cable -> Eye Diagram | Clock -> Ch1; Data0 -> Ch2; Data1 -> Ch3; Data2 -> Ch4; Rec Length -> 8M; CRU -> PLL; TP1 -> True; TP2 -> True'.

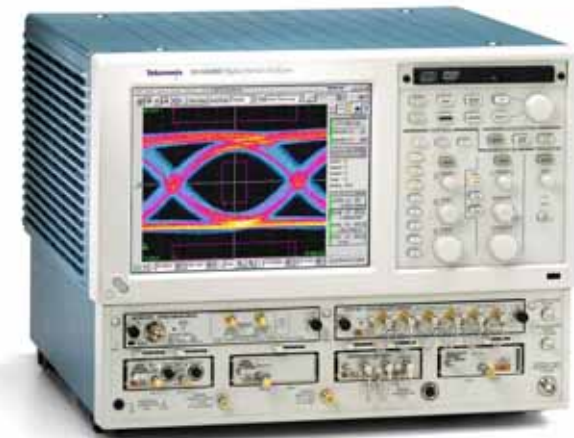
The screenshot shows the 'Configure - Cable' dialog box in the TDSHT3 v1.3 software. The 'DTG Method' tab is active. The 'Pattern List' is set to '1920X1080p 60Hz 8Bit Gray...'. The 'DTG' section has a button for 'Outputs'. The 'Jitter Insertion' section has radio buttons for 'DTG (Internal)' (selected) and 'AFG'. The status bar at the bottom indicates: 'Cable -> Eye Diagram | Clock -> Ch1; Data0 -> Ch2; Data1 -> Ch3; Data2 -> Ch4; Rec Length -> 8M; CRU -> PLL; TP1 -> True; TP2 -> True'.

HDMI Direct Synthesis method will be available under HT3 software



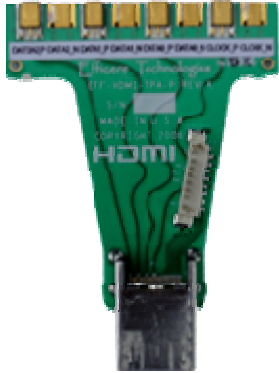
Sampling Oscilloscope

- Sampling Oscilloscope for TDR Measurements
 - Industry leading performance
 - Innovative capabilities using I-Connect software.
 - DSA8200/TDS8200 sampling mainframe
 - 80E03 Sampling Module (1)
 - 80E04 TDR/T Module (1)
- Cable tests
 - Cable inter-pair and intra-pair skew
 - Impedance test
- Sink tests
 - Differential impedance test

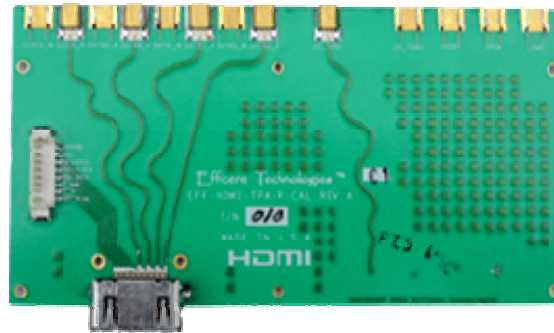


HDMI Test Point Adapters from Efficere Technologies or from Tektronix

- Order a complete set as ET-HDMI-TPA-S www.efficere.com



TPA-P (Plug fixture)

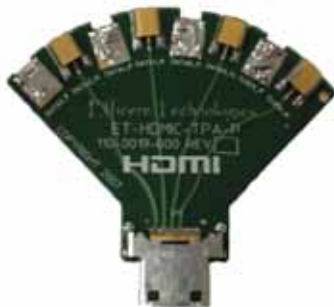


TPA-R (Receptacle fixture with TDR calibration traces)



Breakout Board with EDID ROM

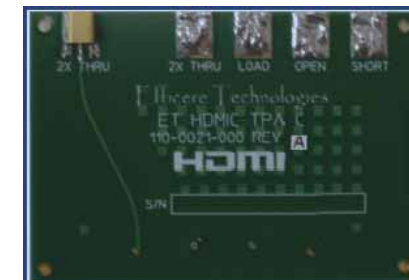
- Mini Type C set as ET-HDMIC-TPA-S



TPA-P (Plug fixture)



TPA-R (Receptacle fixture)



TPA-C (Calibration fixture)



Additional Resources

- <http://www.hdmi.org>
- <http://www.tektronix.com/hdmi>
- High-bandwidth Digital Content Protection
 - <http://www.digital-cp.com/>
- Video Electronics Standards Association
 - www.vesa.org



THANK YOU